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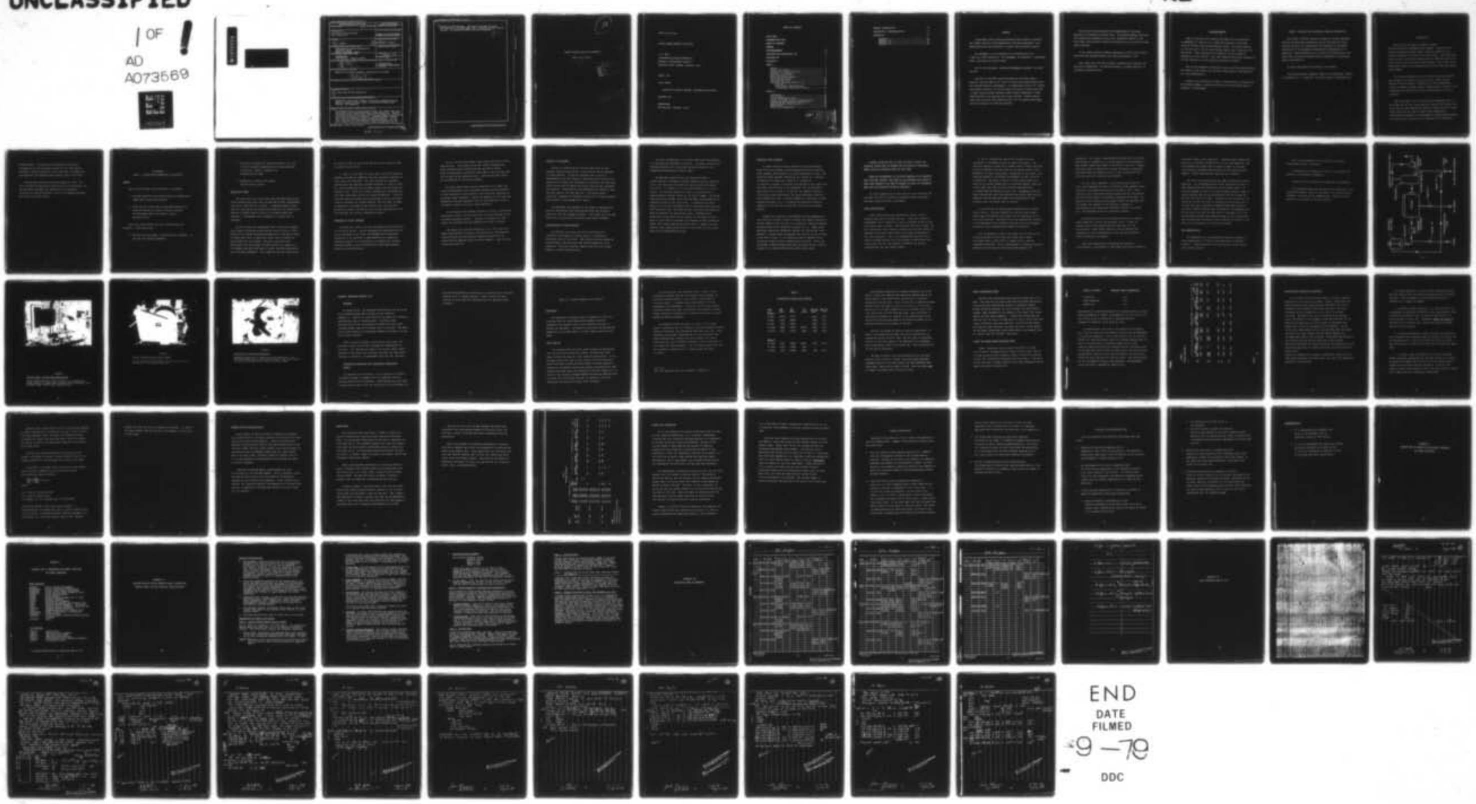

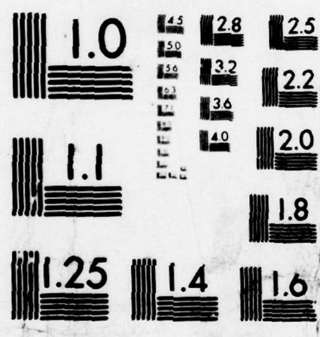
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A prototype rotary vacuum precoat filter unit (RVPF) was built and tested with concentrated human waste dewatering. Results confirmed earlier pilot plant studies with respect to filtration rates and filter and consumption. Suspended solids removal was virtually complete, mostly above 99.9 percent. It was also found that the feed material degrades rapidly over the first several days and filtration rates increase but not as

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rapidly as TSS decrease. The report includes pictures and drawings of the equipment and a proposed purchase specification. An Operations Manual was also prepared.

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ROTARY VACUUM PRECOAT FILTRATION

DAAK 70-77-C-0121

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DAAK 70-77-C-0121

ROTARY VACUUM PRECOAT FILTRATION

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RESEARCH & DEVELOPMENT CENTER

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AUGUST 1979

FINAL REPORT

APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED

PREPARED FOR:

USAMERADCOM

FORT BELVOIR, VIRGINIA 22060

TABLE OF CONTENTS

SUMMARY

A prototype rotary vacuum diatomaceous earth precoat filtration unit (RVPF) was built from commercially available components, with modifications by the contractor to handle fiber-containing wastes.

The equipment is all contained on an aluminum skid with 6 feet by 8 feet dimensions. All equipment, as specified, is explosion proof, including the control panel.

Cost of the equipment, exluding developmental expense, was about $42,900.

The size of the RVPF itself was based on work done under a previous contract DAAG 53-75-C-0276 in which concentrated human waste was filtered without pretreatment. In performance tests at Ft. Belvoir with similar material (it varies widely from batch to batch and time to time) this prototype produced results quite comparable to those obtained during the previous pilot plant studies. Actual precoat cake width was wider than specified and 10 to 25 percent more waste could be filtered than had been planned.

The previous study indicated that degradation of the waste resulted in increased filtration rates. The present studies confirmed that substantial degradation does occur, apparently mostly in the first week, and filtration rates do increase but not as rapidly as TSS values decrease.

In all cases virtually complete separation of TSS, usally better than 99.9% was achieved whether the feed was degraded or not.

This report also includes drawings, proposed specifications and raw data as appendices. An operations manual, already supplied, is included by reference only.

ACKNOWLEDGEMENTS

Most of the field work testing this RVPF unit was performed at MERADCOM, Ft. Belvoir, Va., under the direction of Dan Lent, original COR and later Gerald Eskelund as COR. Also participating in the work at Ft. Belvoir were Charles Chapin, Mrs. Janet Hall and Don Miller. Their assistance was essential to the successful completion of the contract. Mrs. Hall deserves particular recognition for her handling of a very difficult analytical program.

Most of the equipment performance testing and field modifications were made by John Leamon, who has since been moved by Johns-Manville to a new responsibility.

Finally, the assistance of Eimco, and specifically Richard Smith and Douglas Lindsay in resolving warranty and vacuum pump capacity problems is acknowledged.

PATENT, COPYRIGHT AND PROPRIETARY DRAWINGS RESTRICTION

This report includes drawings provided the Process Equipment Division of Envirotech Corporation and by Johns-Manville Sales Corporation which are considered to be necessary to the proper description of the equipment furnished and understanding its operation. Said drawings may not be used for purposes other than those above without the express written permission of Envirotech and/or Johns-Manville.

No other copyrights are involved in this report

The revolving knife assembly, shown in J-M drawing No. 56612-2 is covered by U. S. Patent No. 3,520,410 issued to Johns-Manville.

INTRODUCTION

The military has need for means to dewater difficult-to-filter suspensions and sludges. Typically these include concentrated human wastes, chemical sludges such as Erdlator blowdown, and certain munitions wastes. Work done under Contract DAAG 53-75-C-0276 demonstrated, on both bench and pilot plant levels, that the rotary vacuum precoat filter (RVPF) using appropriate grades of diatomaceous earth filter aids will dewater such sludges.

In a single operation, clear liquid and damp solid phases were produced, the latter having dry solids levels ranging between 30 and 50 percent. Generally this was accomplished without the need for added chemical conditioning, although it was recognized that conditioning might be advantageous in certain instances.

The final report for the earlier work recommended that a prototype unit be built which would be suitable for military use. Since some of these suspensions contain fibrous materials, stock filter units are not able to handle these suspensions. Johns-Manville pioneered the development of specialized equipment for, and now has fifteen years of experience with dewatering

fibrous wastes. Furthermore, Johns-Manville has working knowledge of all the available filters of this type and was therefore a logical choice for prime contractor to develop the prototype unit for MERADCOM under Contract DAAK 70-77-C-0121.

The contract covers two principle phases or tasks. The first includes the design and construction of the prototype unit, and the second includes test operation of the equipment, furnishing of operating manuals, training of MERADCOM personnel and writing this final report.

DISCUSSION

PHASE I - DESIGN AND CONSTRUCTION OF EQUIPMENT

Design

Only two firm design criteria were set by MERADCOM:

1. The test material to be filtered would be concentrated human waste without pretreatment.

2. Since the unit might also be used experimentally on munitions wastes, all electric motors, controls and switchgear were to be Class 1, Group D explosion proof.

There were other factors for which consideration was requested. Among these were:

1. Minimize size and weight to facilitate air transport, if and when that becomes necessary.

2. Corrosion resistance for possible exposure to a wide variety of aqueous suspensions with varying degrees of salinity, acidity, alkalinity or combinations of these.

3. Capability to handle both fibrous and non-fibrous solids.

Sizing the Filter

The pilot plant work established that the RVPF would filter either concentrated human waste as received or after pretreatment with ferric chloride and a polymer. A somewhat smaller filter would be required for the conditioned waste but the logistics for chemical treatment made filtration of untreated waste more desirable. Pretreatment can be adopted at a latter date if necessary.

The pilot plant work established that a three foot diameter drum having a filtering surface one foot wide (3 foot X 1 foot) would have an average filtering surface with 3 inch cake of about 10 square feet which is sufficient filter area to handle the daily wastes for 250 persons. The pilot plant work also established that even though the waste varied with aging, with the seasons, and just from batch to batch, the RVPF performance was relatively unaffected. More important were the selection of

the correct grade for filter aid and use of the revolving knife to remove fibrous solids.

A 3 foot X 1 foot RVPF is a very small filter by industrial standards and several companies have such equipment available as pilot plant test equipment. For such purposes the equipment manufacturers use generally accepted standards or rules of thumb for sizing accessories such as vacuum pumps, filtrate pumps and receivers, etc. While not a filter manufacturer, Johns-Manville also uses these same criteria for sizing accessories. Since the filtering area had already been established, a set of bid specs could be developed for bidding purposes. The bid specs included in Appendix II are based on the original set, but have been modified to reflect the as-built unit so that characteristics of the prototype unit could be duplicated readily.

Selection of Filter Supplier

Bid specs were sent to the four principle RVPF manufacturers in the United States. Options considered by Johns-Manville were (1) the purchase of the filter and accessories as individual components to be installed by Johns-Manville on a specially designed platform, or (2) purchase of a complete unit already platform mounted to which Johns-Manville could make necessary additions and modifications.

At the time bids were taken, light weight was still a prime consideration. Since three of the four filter manufacturers offer stainless steel construction and the fourth offers fiber-filled plastic, the latter could offer a unit weighing only half as much as the competing units. This was one major factor in the selection of the filter supplier.

The other major factor was the favorable bid to mount the filter and accessories on a specially designed aluminum platform or skid according to Johns-Manville specifications, resulting in a further weight reduction. Having the supplier do this work was estimated to be less expensive than for Johns-Manville to do it in house or contract to have it done separately.

On this basis Eimco Process Machinery Division of Envirotech Corporation (Eimco) of Salt Lake City, Utah was selected as the principle equipment supplier. Approval to proceed with this vendor was obtained from both MERADCOM and DCASMA in Denver.

The basic unit price was $34,456.00 f.o.b. Salt Lake City. Eimco also supplied, as extras, the starters for Johns-Manville supplied motors and the specially designed mounting for the Johns-Manville supplied revolving knife assembly. Cost of these extras was $3,017.00.

Delivery of Equipment

Failure to understand the internal operations of this supplier caused serious delays in the delivery of the equipment to Johns-Manville. We were not advised that no parts or subassemblies would be ordered or fabricated until all of Eimco engineering drawings were completed and certified, the last step being delayed several months while minor details were discussed and resolved. Johns-Manville had understood long delivery items had been ordered, but they were not. This delay caused particular problems with obtaining 200-208 volt 3 phase explosion proof motors on what became short notice.

The equipment was inspected at the vendor's manufacturing facility and several minor deficiencies noted and corrected before the unit was shipped to Denver. This vendor does not have facilities to make actual filtration tests before shipment.

Modifications by Johns-Manville

As received, the filter unit had no facilities for preparation and pumping of precoat slurry, or pumping of unfiltered feed to the filter. Also lacking were the revolving knife assembly and drive used when fibrous wastes are to be dewatered. The other important addition was fork lift guides needed to improve field handling.

For slurry preparation, a 60 gallon 316SS tank and agitator, were obtained and installed on the skid. As noted, a starter and overload protection for this mixer had been provided in the explosion-proof electrical control panel.

To pump both precoat slurry and unfiltered feed, a Moyno[R] pump and 1 horsepower variable speed drive were installed on the skid and piped and valved so that feed could be pumped from either the precoat tank or an external feed tank or other source. The variable speed drive motor is controlled by a manual-off-auto selector switch at the control panel. The manual mode is strictly on-off, while the auto mode is controlled by an adjustable probe in the filter bowl. In practice, the motor speed is set so that the pumping rate is slightly faster than the RVPF filtering rate. The level control then starts and stops the motor to maintain the desired bowl level. Because of the sensitivity of the level control system ($\pm$ 1/16-inch) it has a built in time delay to decrease the frequency of motor starts and stops, which could generate sufficient heat to damage the motor. Ideally, motor speed should be set so that there will be no more than 10 to 15 stop-starts per hour.

Revolving Knife Assembly

To remove fiber-containing solids from the diatomaceous earth filter aid precoat, a custom designed and built revolving knife assembly was attached to a fixture provided by Eimco. The revolving knife assembly, covered by U.S. Patent No. 3,520,410, is shown on J-M drawing No. 56612-2. It consists of 12 Stelite® 6K blades 1-1/16-inch wide mounted on type 316SS arms and shaft, and driven by a 1/3 horsepower 1750 rpm explosion proof motor with a V-belt. As set up, the assembly removes a 12-1/16-inch wide accumulation, but using additional 1/16-inch thick spacers the "cut" could be widened to 12-3/4-inch if this becomes desirable, e.g., to increase the effective filtering capacity of the unit when a cake wider than 12-inch has been applied.

Because this revolving knife assembly is very dangerous if the knives are allowed to come in contact with hands, clothing or foreign objects while the unit is in operation, special attention has been given to the design of the guard for it. Under normal operating conditions, accidental contact with the knives is not possible. Contact would be possible near the end of the run when little cake is left, if the revolving knife is manually fully retracted, since the guard retracts with the knife. Then a gap of perhaps 2-inches between guard and cake would permit a hand or fingers to be inserted and serious injury would result.

Standard practice shall be that the motor driving the revolving knives must be stopped and the knives be stationary before they are retracted from the cake face.

Under no circumstance is the knife assembly to be operated with the cover removed, and under no circumstance are sticks or other such objects to be used to attempt to clear the discharge part with the revolving knives in operation.

The knife assembly can be shut down for brief periods, and the cover can then be removed for cleaning without seriously adversely affecting filter performance.

Field Modifications

After modifications were completed at Denver, several attempts were made to precoat the unit. These were generally unsuccessful due to inability to pull an adequate vacuum to hold the precoat layer in place. This was duly reported to Eimco, who after consulting their supplier, advised that the pump should be adequate at sea level (Fort Belvoir) but might be marginal at 5500 feet elevation. This is an unacceptable condition for a general purpose portable unit, but because of contractual time constraints, the unit was shipped to MERADCOM for further investigation into the vacuum problem.

It may be recalled that one of the original criteria considered in the design of the unit was to be weight. One alternate offered by Eimco was a compact plastic vacuum pump made by SIHI of Buffalo, New York which is 300 pounds lighter than a comparable all metal vacuum pump. Recognized at the outset, as a possible problem is its maximum displacement of only 34 cfm at 20-inches Hg. The usual criterion by which vacuum pumps are sized is 4.0 cfm per square foot of filtering surface, requiring in this case just under 40 cfm by Eimco's calculation of 9.5 square feet of effective filter area. Discussions with the vendor established that Eimco believed the plastic pump would be adequate, and the pump was ordered with the proviso on the purchase order that Eimco would so warrant.

At Fort Belvoir the vacuum pump performance was no better than at Denver. This was observed by Eimco who then loaned a larger pump from another pilot plant so that evaluation of the unit could continue. The plastic pump was subsequently returned to the manufacturer for evaluation and was found to be damaged internally, which substantially reduced its capacity.

With the substitute pump it was found that the area of the filtering surface on which cake was formed was at least 12.5 square feet, rather than 10.0 square feet or less as originally specified. This is advantageous in terms of filtering capacity but does require more vacuum pump capacity for

precoating. As a result, Johns-Manville decided that the plastic pump should be replaced with a 60 cfm pump with the difference in cost between pumps being added to the price of the unit. Because the larger pump is substantially larger physically, a specially fabricated base was supplied to fit it onto the existing skid. This new pump still requires final checkout.

With the filter operable, it was quickly found that the drive which advances the knife or revolving knife assembly toward the filter drum moved foward at much too fast a rate. Eimco normally uses a fractional SCR-controlled drive for this purpose but such drives cannot be obtained in explosion proof form. An explosion proof Graham motorized speed reducer was designed into the system, but because of long delivery a temporary non-explosion proof Graham was installed to permit unit check out. The permanent drive has since been received.

The Graham drive has a 60 division dial from 0 to maximum output speed of 5 rpm for the permanent drive. As set up, maximum usable knife advance rate was less than 2 of the 60 divisions. Under these conditions control accuracy and repeatability were unsatisfactory, which was duly relayed to Eimco as designer and supplier.

After some negotiations, Johns-Manville agreed to field-install a countershaft or jack shaft which would provide an

additional stage of gear reduction. Available space allowed only about a 6:1 reduction instead of the 10:1 or more hoped for, but this expanded the Graham control range to about 20 divisions which should be adequate when working with low rates of knife advance. Higher knife advance rates are not a problem.

One other field modification was made to facilitate routine operation. All diatomaceous earth filter aids tend to crack to some degree during the application of the precoat layer. If cracking becomes so severe that loss of vacuum occurs, chunks of filter cake may fall out and occasionally the entire cake may fall off into the filter bowl. Cracking is due in large part to drying out of the cake after it emerges from the slurry pool in the bowl and may be overcome by applying additional moisture. So-called "fogging" nozzles were installed on the emergence side of the drum to wet down the cake after it has begun to dry out. The available nozzles were somewhat coarse for this service and must be cautiously regulated to avoid washing the surface of the cake, but are effective in controlling cracking.

The Completed Unit

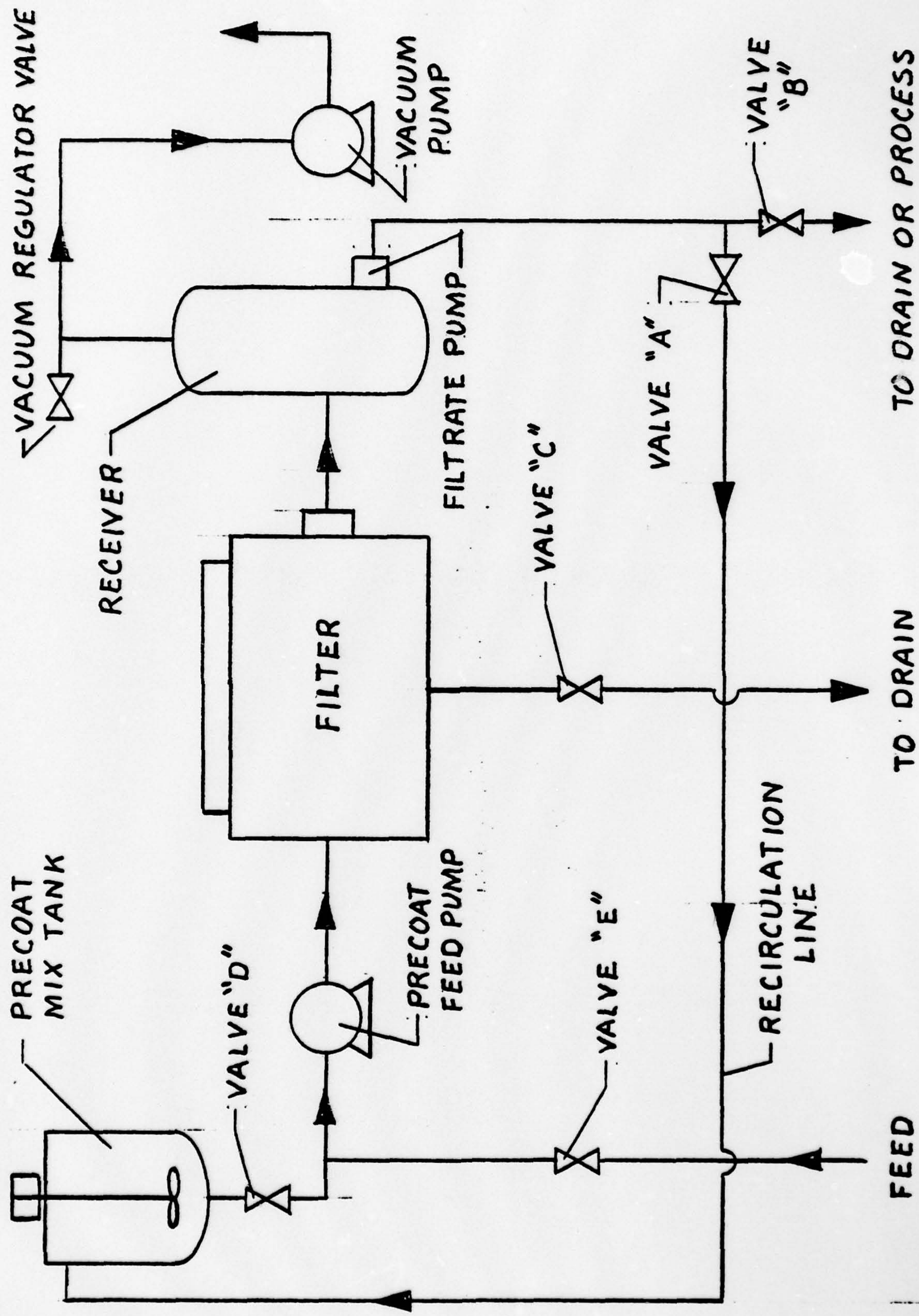
The completed unit, as modified and ready for checkout, is shown schematically in Figure 1 and pictorially in Figures 2 through 5. These pictures do not show the new, larger vacuum pump in place however.

Cost of the completed unit as shown, but excluding developmental costs, was $42,900.

A complete set of drawings of the unit, as supplied and modified, is contained in Appendix I.

Captions for the pictures are largely self- explanatory.

Since detailed operating instructions are contained in the instruction manuals, which are included in this report only by reference, they will not be repeated here. Results of test operation are included in the next section.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VALVE "C"
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TO DRAIN
PRECOAT MIX TANK
VALVE "D"
PRECOAT FEED PUMP
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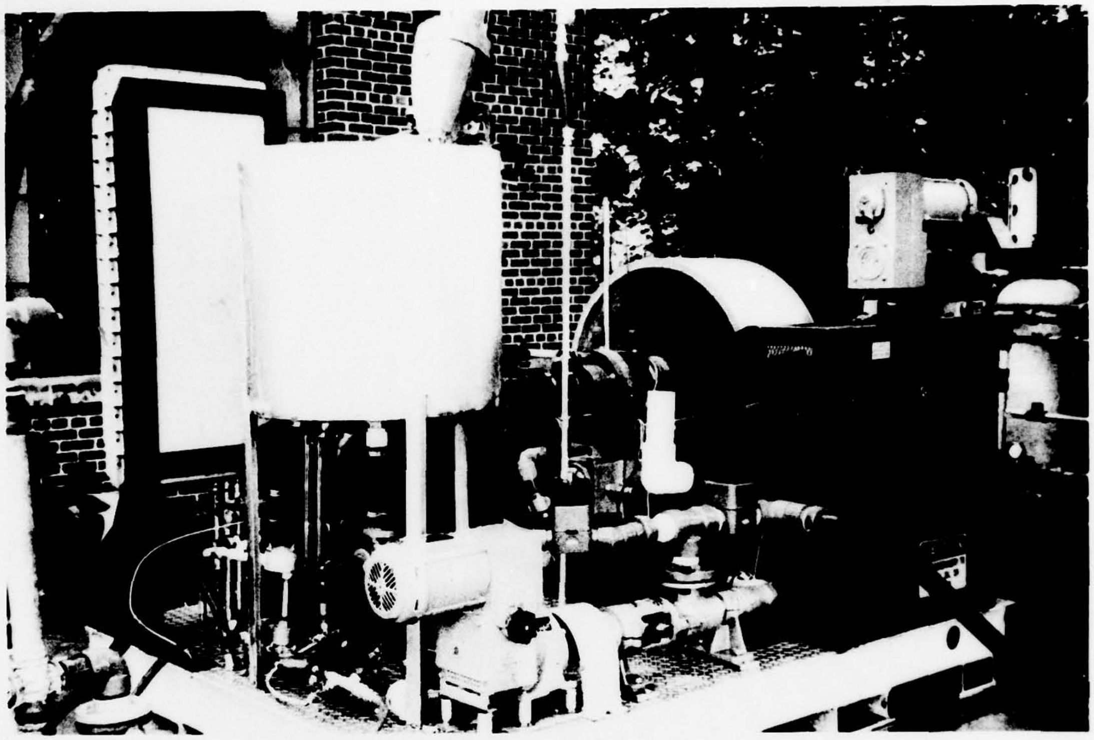

FIGURE 2

Precoat Tank - Filter Feed Pump System

Filter with filter aid cake in place is in background. Speed reducer in upper right controls drum rotational rate. Guarded "cage" houses bowl agitator drive.

FIGURE 3

Rotary Vacuum Precoat Filter (RVPF)

Filter drum and cloth septum are clean and ready for beginning of precoating operation.

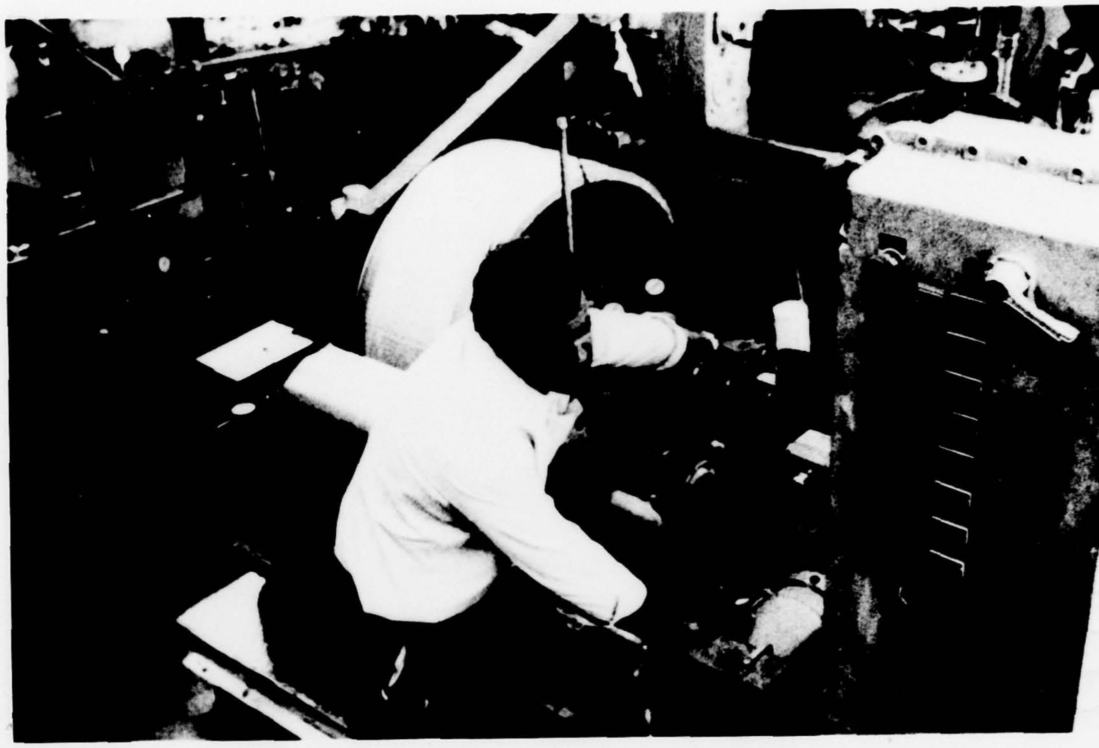

FIGURE 4

Beginning of Precoating Operation

MERADCOM technician is controlling this operation. Pipe directly behind him is level control sensor and level control for filter feed pump start-stop is directly below.

Drawings, Operating Manuals, Etc.

Drawings

As noted earlier, the purchase specifications for the filter unit as modified have been included in this report as Appendix II. Used as is, they would buy the basic unit including modifications made by Johns-Manville. To detail those modifications the set of blueprints included with this report includes changes made both in Denver and in the field. The specs and drawings contain the information needed to purchase a similar unit or parts thereof.

These drawings represent a joint effort with Eimco, who provided a master set of their drawings for modification to as-builts. All drawings are keyed to the serial number, 81631, assigned to the filter unit by Eimco, and they will have master drawings, as modified, if replacement parts are ever required.

Installation Operation and Maintenance Instruction Manual

As required by the Contract, six (6) copies of the Manual have been provided to MERADCOM with the equipment, and are included herein only by reference. These manuals are also keyed to Eimco serial number 81681 for this filter unit and contain not

only detailed operating instructions but complete parts lists and complete sets of reduced drawings. Master copies have been retained by both Eimco and Johns-Manville for possible future reference.

PHASE II - INITIAL OPERATION AND TRAINING

Objectives

The objectives of Phase II were to demonstrate that this prototype RVPF unit would effectively dewater difficult suspensions and sludges, and to train MERADCOM personnel to operate the equipment. Furnishing of operating instructions and completion of the Final Report are also integral parts of this Phase.

Test Material

The previous bench and pilot plant studies had established that the RVPF could effectively dewater "concentrated human waste" without the need for prior chemical conditioning. In the previous studies this was so even though wide variations were found from batch to batch and from season to season because of changes in the chemical stabilizing systems (preservatives) used. Concentrated human waste was specified as the test medium for the Phase II test program, because MERADCOM foresees an eventual need to handle this and similar material in connection with Army watercraft operations and certain other programs.

The previous work also indicated that, in spite of the preservative systems used for such wastes, aging changed the filtration characteristics - with apparent improvement in filtration rates. A separate study was included to further investigate this phenomenon. Some other similar small studies originally called for under the contract were deleted by mutual consent because of difficulties in obtaining test materials and because of funding problems.

Two separate batches of waste were used in this phase. Table 1 illustrates the wide variability between batches and also clearly illustrates that degradation does occur with age. Total suspended solids (TSS) determinations on this unfiltered (and almost unfilterable) material are very difficult but these determinations, all by MERADCOM personnel, were in duplicate or triplicate with good agreement. All the MERADCOM analytical data are included in Appendix III.* Average values are shown in Table 1.

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*Raw RVPF operating data are included in Appendix I.

TABLE 1

CONCENTRATED HUMAN WASTE BATCHES

Date	TSS (mg/l)	COD (mg/l)	TS (mg/l)	TSS LOI (mg/l)	TSS LOI (%)
Batch 1					
2 June	13294	47733		11019	82.9
5 June	8228	36560		7496	91.1
6 June	4744	32667		4248	90.2
13 June	9468	21795	10710	6004	70.9
14 June	5263	19740	6380	3579	68.0
Batch 2					
16 June	5194	16589	11675	4706	90.6
23 June	1679	11500	7723		
30 June	1540	11888	7970	842	54.7

Some apparent anomalies are probably accounted for by the manner in which the material was stored and handled during the test program. A 1000 gallon batch was stored in a covered underground concrete tank. Prior to each use, a gasoline powered macerator-pump was used to churn up the contents of the tank, some of which was then transferred to a 500 gallon rubber "day tank" from which the RVPF feed was drawn. Some variations in feed quality probably are related to the effectiveness of the initial churning each day despite the conscientiousness of the technician handling this aspect of the work.

Even so, the effect of aging is clearly established. In spite of the preservatives used, TSS and COD degradation is substantial during the first week, and much less so thereafter. Most of the COD loss appears to be associated with suspended solids destruction since total solids (TS) after correction for TSS are fairly consistent.

The data in Table 1 give some indication as to why aged material might filter at a higher rate even though degraded suspended solids of this type usually are less permeable than fresh ones. There are far fewer of them. Both the nature <u>and</u> the amount of solids govern filtration rates.

Filter Performance Tests

Initial filter performance was determined using Batch 1 as feed. This was also the period when serious precoat application difficulties were encountered because of inadequate vacuum. Precoat formation was poor but once in place with waste solids present, cake permeability was reduced to the extent that vacuum supply was more nearly adequate. A substitute vacuum pump was used for the runs with this same batch on June 13 and 14 and much higher filtration rates were observed. But TSS and COD values are also far lower than when the stock was fresh, so the effect of the larger vacuum pump, while undetermined, was probably less of a factor than the "thinner" feed stock.

Filter Aid Grade Versus Filtration Rate

Table 2 summarizes the work done with Batch 1 as feed. Three grades or permeabilities of filter aid were used, and one of these grades was also treated to apply a coating of aluminum hydrate (for convenience designated here as $Al(OH)_3$). The three filter aids have a nominal range of clear water permeabilities of about 300 percent as shown here.

Filter Aid Grade	Relative Water Permeability
CELITE 512	0.65
HYFLO SUPER-CEL	1.00
CELITE 503	1.80

Application of a coating equivalent to 2 percent $Al(OH)_3$ to HYFLO would be expected to reduce its permeability to 0.80 to 0.90. (If the $Al(OH)_3$ is not a coating but a separate phase the permeability would be in the range of 0.20.)

As noted earlier, and also in the report of the previous work, both the nature and the amount of solids must be considered in filtration processes. This is particularly true of the RVPF. CELITE 512, HYFLO and Coated HYFLO all produced substantially the same filtration rates on relatively unaged Batch 1 feed. Similarly HYFLO and CELITE 503 produced similar filtration rates on the same Batch after almost two weeks aging, and the rates are approximately doubled; but as seen from Table 1 the TSS and COD values are less than half the initial values. This could account for the increased filtration rates observed. The subsequent study with Batch 2 appeared to confirm this.

TABLE 2

ESULTS FROM BATCH 1

	Analytical Data									
	TSS (mg/l)		COD (mg/l)		TS (mg/l)		LOI (%) (1)		Cake	
es	Feed	Filtrate	Feed	Filtrate	Feed	Filtrate	Feed	Filtrate	% Moisture	% LOI
	13294	~0	47733	10104	-	9547	82.9	44.9	45.8	0.3
	-	-	-	16613	-	13100	-	47.8	54.2	16.3
(2)	8228	6.7	35560	15829	-	11387	91.1	44.7	45.3	19.0
(3)	29406	-	55227	-	-	-	81.8	-	-	-
(4)	4744	46.5	35100	16600	-	13153	90.2	50.6	46.0	15.6
(5)										
	8468	188	21795	5410	10710	2730	70.9	51.2	44.5	21
(6)										
	5263	286	19740	5972	6380	2910	63.4	49.2	47.6	15.2

rgance.

Liquid-Solids Separation Efficiency

By its nature the RVPF process makes a virtually complete separation of TSS from the filtrate. However, each filter aid grade has some minimum sized TSS particles which will not be retained at the surface of the filter aid cake - this size increasing as the permeability of the filter aid grades increases. Because of the initial thickness of the precoat layer, the effect of this passage of fine particles may not be observed for some time, but if the cycle is continued long enough, one or both of two effects can be observed. If the filter aid is open enough and the TSS particles are fine enough the latter will pass through the cake and be observed as increased TSS values in the filtrate. This effect can be seen in the filtrate data for the runs made June 6 and 13 where degradation decreased the particle size for the second of the two HYFLO runs resulting in a higher TSS value, and the run made on June 14 with

CELITE 503. Because of its greater permeability CELITE 503 will pass larger particles than HYFLO does, and higher TSS values were observed in the filtrate.

The second possibility is that TSS not retained will only partially pass through the cake and gradually plug its internal structure. This phenomenon is called penetration and is important for a number of reasons:

1. Favorable process economics, i.e., cost of filter aid, is dependent on retaining the TSS on or near the surface so that a minimum knife advance (cut) is required, taking with it a minimum amount of filter aid. (Remember, amount and nature of TSS govern the filtration rate, rather than filter aid grade, within quite wide limits).

2. Continuing penetration beyond the depth of the cut per drum revolution will gradually clog the cake pore structure, and an increasing loss in flow rate through the cake will result. This could result in inability of the filter to handle its design load.

3. In severe cases of penetration, the cake may become almost completely impermeable and the cake surface will actually be washed or sloughed from the drum due to the washing action caused by drum rotation and bowl agitation. This not only results in zero filter capacity, but it may also result in fouled filter septa and other undesirable side effects.

Assuming that a proper grade of filter aid has been selected to control penetration, and ignoring the runs of June 13 and 14 with badly degraded stock, all other runs effected at least 99 percent TSS removal and most were better than 99.9 percent. This equals or betters the performance observed in the earlier pilot plant tests.

The RVPF also effected substantial reductions in COD. However, the degree of removal, ranging between 75 and 40, is strongly affected by, and decreases with aging of the stock.

By contrast, TS values, after correcting for TSS effects, were relatively unaffected by the filtration process. Corrections were made as follows:

$$\frac{TS_F - TSS_F}{TS_i - TSS_i} \times 100 = \%$$

where:

TS_F & TSS_F are filtrate values

TS_i & TSS_i are feed values

% TS Change is + for increases and - for decreases

Even though Batches 1 and 2 were quite different in characteristics, TS changes were plus or minus 13 percent from initial values. To determine whether observed increases (i.e., plus values) are real would require making a full material

balance for which not all data needed are available. In view of the small changes observed such data would appear to be of very limited value.

Removed Solids Characteristics

Since removal of TSS by the RVPF is essentially complete, the removed solids or "cuttings" contain the TSS along with small amounts of filter aid and moisture. Since the moisture also contains dissolved solids (TDS) in the same concentration as the filtrate, simple drying at 105°C results in dry solids values for the cuttings that are somewhat higher than if a cake washing device had been in use. Similarly losses on ignition (L.O.I.) will be low because the TDS retained in the cuttings are about 50 percent inorganic.

Moisture, as defined above, ranged between 42.6 and 54.2 percent for ten cuttings samples. This is unusually low for cuttings and may be due to the high degree of pulverization produced by the revolving knife assembly. Since "dusting" was a problem, the rotational speed of the assembly will be slowed down and this is expected to increase cake moisture to a more normal 50 to 60 percent.

Aging Tests

The filtration tests with Batch 1 tended to confirm the earlier findings that filtration rates improved as the waste aged. But the earlier studies had too few data to determine why this might be so. As originally planned, the tests with Batch 1 also would not have covered a sufficient period to observe why this might be so. As the program actually developed, the data for Batch 1 in Table 1 began to provide a much better idea of why filtration rates could improve.

Batch 2 was obtained specifically to study the effect of aging. Because of the limited volume of the underground tank only three runs, i.e., fresh, after 1 week and after 2 weeks, could be made. The data for Batch 2 in Table 1 indicate, however, that the same sort of degradation had occurred.

As seen in Table 3, the three filter runs, all with HYFLO filter aid, follow the same patterns observed in the original pilot plant work and Batch 1 work with new unit. Now, however, the feed data for Batch 2 indicate that most of the degradation occurs in the first week, and the filtration rate data appear to correlate well with the degree of degradation of the feed.

The data for the third run may indicate that additional degradation may have adverse effects on filtration rates, but with only a single filtering cycle such a conclusion would be speculative.

There would appear to be some real advantage, in terms of both filter capacity and filter aid consumption, to allowing the waste to age several days. After seven days, the filtration rate more than doubled, meaning that a filter of a given size could filter twice the volume of waste. This also has the effect of decreasing the amount of filter aid required per unit volume by half or more, as discussed below.

TABLE 3

TEST RESULTS FROM BATCH 2

BATCH 2

			Operating Data					Analytical Data									
								TSS (mg/l)		COD (mg/l)		TS (mg/l)		LOI (%) (1)		Cake	
Date	Filter Aid	Test No.	Knife Adv. Mil/ Min	Drum Speed RPM	Flow Rate GSFH	F/A Consumed Lbs. /1000 Gal.	Notes	Feed	Filtrate	Feed	Filtrate	Feed	Filtrate	Feed	Filtrate	% Moisture	% LOI
6/16	Hyflo	4573-57	5.9	0.46	3.53												
			5.5	0.46	3.64												
			5.5	0.46	3.51		(2)										
			5.5	0.46	3.61												
			5.5	0.46	3.94		(3)										
			5.4	0.46	4.26												
			5.55	0.46	3.75	153		5194	1.3	16589	6666	11675	5725	63.95	42.35	52.8	10.3
6/23	Hyflo	4573-58	5.4	0.47	9.65												
			5.4	0.47	7.96												
			5.4	0.47	6.93												
			5.4	0.47	6.78												
			5.4	0.47	9.15												
			5.4	0.47	6.6												
			5.4	0.47	6.7												
			5.4	0.47	7.68	86		1679	4.5	11500	7112	7723	5505	51.2	38.4	52.1	12.5
6/30	Hyflo	4573-59	5.4	0.62	6.58	86		1540	1.1	11888	7388	7970	6880	42.5	37.2	44.6	10.2
			5.0	0.62	6.23	84											
			3.3	0.72	5.38	63		-	1.7	-	-	-	-	-	-	43.1	13.2
			3.3	0.72	5.35												
			3.3	1.15	5.84												
			3.4	1.15	5.85	61		-	1.2	-	-	-	-	-	-	42.6	15.4
			5.6	1.15	7.44	79											

NOTES:

(1) LOI based on TS.

(2) Acidify to pH 3 for best precoat.

(3) Rates are averages.

Filter Aid Consumption

All of the cycles in this latest study used about the same initial operating conditions, i.e., 30 percent submergence, 2 minutes per drum revolution and approximately 5.5 thousandths of an inch (mils) per minute knife advance. Because of the limited amount of feed material and because the specific objective of this study was to determine the effect of feed degradation, filter aid consumption could not be optimized. In the third run on Batch 2 some limited work was done toward optimization, and it does appear that a balance between filter aid consumption and filtration rate may have been bracketed.

For convenience in calculating filter aid use, rate of knife advance (k.a.) is stated in mils per minute. The volume of filter aid used per unit of time can then be readily calculated. Volume used X 20 lbs per cubic foot converts knife advance to weight of filter aid used. And this, in turn, times cost of filter aid per unit weight converts to the cost of filter aid for the same unit of time. When the number of gallons filtered in that period of time is known, then cost of filter aid per 1000 gallons (of feed) filtered is readily calculated.

However, in terms of effective operation, the distance the knife travels during each revolution of the drum, in order to remove accumulated and penetrated solids, is more important.

With a drum speed of about 2 minutes per revolution the k.a. of 5.5 mils per minute becomes 11 mils per revolution which is quite high.

Until the knife advance drive was changed late in the work with Batch 2, there was no way to have accurate control of knife advance rates. Hence, early filter aid consumption data are relatively meaningless large numbers. How much so, can be estimated from the data for the third run on Batch 2. Here other drum rotational speeds and k.a. rates were tried with indications that k.a. rates between about 4.0 and 5.5 mils per <u>revolution</u> would be adequte for this well aged waste. These calculate to 60 to 85 pounds of filter aid per 1000 gallons of waste. Calculated values from the previous pilot plant work with this same filter aid grade and aged material ranged between 38 and 95 pounds per 1000 gallons. The new data appear to provide reasonable confirmation of the earlier pilot plant work.

GENERAL OBSERVATIONS

Operation of the RVPF unit at Fort Belvoir was generally in line with expectations. However, three potential problem areas were identified:

1. With the revolving knife assembly operating at a speed of 1750 rpm, considerable dusting of the removed material occurred. Because of its nature this material is classed as hazardous and presents an environmental problem. As noted earlier it is planned to reduce the speed of this assembly to about 1200 rpm which, based on previous experience, should minimize dusting.

2. While the filter picks up substantial amounts of fiber with the other suspended solids, some fibers are not picked up and tend to accumulate in the filter bowl. Both TSS and COD values are affected, with TSS values being affected more. On June 5, after about 6 hours, TSS values had increased from about 8200 to 29,400 mg/l, or about three and a half times. On the other hand, COD only increased from about 36,500 to 55,000 mg/l, or less than twice. The volume of these solids can be made quite small, 10-15 gal if the filter feed is stopped and the contents of the bowl filtered

down to where contact with the drum is lost, but some additional work on disposal of this "heel" is indicated. Regrinding and returning to the feed tank is one possibility.

3. The vacuum pump discharge air-seal water separator furnished by the vendor is ineffective because velocities are too great to permit effective phase separation. The result is a substantial spray of water which might be contaminated. It is anticipated that fittings properly selected for the new, larger pump will effectively resolve this problem.

4. The use of fogging sprays during precoating and the desirability of having finer ones was noted earlier. The sprays are mounted in a temporary setup and are not shown on drawings and parts lists.

CONCLUSION AND RECOMMENDATIONS

From the foregoing, the following conclusions have been drawn:

1. Commercially available components can be assembled to make a RVPF unit satisfactory for dewatering concentrated human waste, with the addition of the revolving knife assembly to handle fibrous wastes.

2. The performance of the unit so assembled under this contract was comparable to that observed in earlier pilot plant studies at Fort Belvoir. Filtration rates, filter aid and consumption, and degree of suspended solids removal were all closely comparable over a range of feed conditions.

3. A study designed specifically to determine the effect of aging of concentrated human waste established:

   A. Despite attempts at preservation, a high degree of degradation of TSS takes place in the first several days, substantially reducing the amount of solids to be removed by filtration.

B. COD associated with those solids is also degraded.

C. Filtration rates to remove the remaining TSS are higher because of the lower suspended solids levels but are not proportionately higher indicating that the remaining solids are more impermeable than fresh ones would be.

4. Despite wide variations in concentration and condition of feed solids the filter effected almost total separation, usually 99.9 percent or better TSS removal, in all cases when using HYFLO SUPER-CEL, a relatively fine grade, as the filter aid.

5. Problem areas relating to incomplete or partial pickup of fibrous material, on the precoat, dustiness of the material removed by the revolving knives, improvement of the air-water separator and muffler on the vacuum pump, and closer control of the fogging sprays during precoat formation all require some additional work to make the unit fully satisfactory for its intended purpose.

Recommendations

1. It is recommended that MERADCOM take title to the equipment which is physically located at Fort Belvoir.

2. It is also recommended that additional funding previously estimated to be about $3,000, to $5,000 be considered to complete the work on the above mentioned problem areas.

APPENDIX I

COMPLETE SET OF DRAWING FOR EQUIPMENT FURNISHED

BY PRIME CONTRACTOR

APPENDIX I

COMPLETE SET OF DRAWINGS FOR EQUIPMENT FURNISHED BY PRIME CONTRACTOR

Eimco Drawings

81681D1*	Filter General Arrangement
81681D200*	Filter & Accessory Platform G.A.
81681D206*	Filter Control Panel Arrangement
81681D207*	Filter Control Panel Schematic Wiring
81681C20	Filter Drive Assembly
202682	Valve Assembly
202683	Bridge Setting Assembly for 7" Valve
202580	Agitator Assembly
202600	Agitator Drive Assembly
47867	Lubrication Assembly for Agitator Pivot
87635	Trunnion Bearing Assembly - Drive End
87636	Trunnion Bearing Assembly - Non-Drive End
81681D29	Assembly Precoat Mechanism
47827	Engaging Mechanism for Precoat Drive
81681D214*	E-Met Precoat Filter & Accessories
81681D213*	Platform Detail
81681C24*	Auxiliary Apron (Revolving Knife Mounting Fixture)
81681B39	Apron

J-M Drawings

56615-2	Precoat Tank
56612-2	Revolving Knife Assembly
56614-2	Revolving Knife Guard
56613-2	Revolving Knife Mounting
56618-2	Knife Advance Drive (Replaces 81681C18)
56623-2	J-M Supplied Piping

* Includes Modifications or Additions made by J-M

APPENDIX II

PROPOSED ROTARY VACUUM PRECOAT FILTER, ACCESSORIES, CONTROL PANEL AND SKID MOUNTING SPECIFICATIONS

General Considerations:

A. The equipment items for which firm price and delivery quotations are requested herein are to be assembled as a RVPF unit for use by the U.S. Army at MERADCOM, Fort Belvoir, Virginia. Pricing is requested on individual items as noted below, with the Buyer retaining the right to select individual items from various sources as necessary to fulfill the purposes of these studies. Vendors may, however, quote also on a complete, preassembled system in which all components meet these specifications.

B. Since the assembled equipment may be transported by air, weight and space limitations are important considerations and reinforced plastics and lightweight corrosion resistant metals may be given preference, where performance is adequate, over heavier materials of construction. This equipment may be used for a wide range of acid and alkaline conditions and aluminum is not acceptable for wetted components.

C. Quotations shall include, in addition to price and delivery, sufficient data on performance, e.g., pump characteristics, power consumption, etc., dimensions, weight and space requirements to permit evaluation as to suitability for the specific intended purpose.

D. The attached "General Provisions" which apply to the prime contact will apply to any Purchase Order awarded to a successful vendor.

E. The Buyer reserves the right to reject any or all quotes.

Description of Items to be Quoted

Item 1. Rotary Vacuum Precoat Filter (RVPF)*

One (1) RVPF 3'0" diameter x 1'0" face width. Low submergence design having not less than 9 sq ft of effective filtering surface. The filter shall include the following components:

1. Filter Tank: The filter tank supplied shall be a 1/4-inch fiber glass reinforced polyester resin tank shell supported by two cast reinforced thermoplastic* end frames. It shall

*Note: Throughout these specifications "cast reinforced plastic" shall be read as "cast reinforced plastic or approved equal".

be supplied with 3-inch flanged bottom drain connection, 3-inch overflow connection with flexible connection, and agitator and drum and scraper motor brackets. The low submergence tank will be designed for not less than 30 percent, and preferably up to 35 percent, circumferential drum submergence.

2. Filter Drum: The cylindrical filter drum supplied shall be of cast thermoplastic construction consisting of eight drainage deck sections assembled between two cast, thermoplastic drum heads. The internal piping shall be capable of filtration rates of not less than 30 gpm total filtration rate at 30 percent submergence.

3. Drive Assembly: The filter drum drive assembly supplied shall consist of a complete drive system, driven by a 1/2 HP Class 1 Group D explosion proof variable speed drive suitable for operation on 208/230/460 volts, 3 phase, 60 hertz electric current to provide filter drum speed of approximately 1/2 to 7-1/2 minutes per revolution.

4. Filter Valve: The filter valve may be of the single or two solution type and shall be provided on the non-drive end of the filter drum and shall consist of cast thermoplastic valve body, bridging, replaceable wearplate, with steel adjusting rods, one or two 2-inch diameter outlet connections, one or two neoprene flexible connectors, and one or two vacuum gauges.

   The filter valve shall have a hydraulic capability equal to or greater than the drum internals.

5. Agitator: A filter tank swinging type agitator shall be provided consisting of two arc driven members with connecting agitation rakes of cast thermoplastic construction. The agitator shall be driven by enclosed connecting rod and cranks with a 1/2 HP Class 1 Group D explosion proof gearmotor suitable for operation on 208/230/460 volts, 3 phase, 60 hertz electric current and to provide an agitation speed of approximately 15-20 oscillations per minute.

6. Precoat Scraper Mechanism: The precoat scraper mechanism shall be provided complete with a scraper blade, 1/4 HP Class 1 Group D explosion proof variable speed advance-drive motor with automatic stop for maximum "in" position and manual retraction. Rate of advance shall be reliably controllable (± 10 percent) between 0.2 and 15 thousandths of an inch per minute.

7. Revolving Knife Assembly:

See drawings 81681C24 (Eimco)
81681B39 (Eimco)
56612-2 (J-M)
56613-2 (J-M)
56614-2 (J-M)

Since this type of filter will be used on some fiber-containing wastes a special revolving knife assembly is to be supplied in addition to the fixed blade designated "scraper mechanism". This assembly will use the same advancing mechanism described in the preceding paragraph (6) and must be compatible therewith.

8. Filter Media: Five (5) cloth filter covers equivalent to Komline-Sanderson No. KS 201 (75 cfm air perm. rating) and two sets of banding material shall be provided.

Item 2. Vacuum Receiver - Filtrate Pump Combination

Since vendors may offer either separate components with connecting piping or combined receiver-mounted pump and receiver, first consideration will be given to components offered as a single package. However, separate components having sufficient merit will be considered. The following descriptions are provided for the purpose of proper sizing.

1. Vacuum Receiver. Shall be of cast or fabricated thermoplastic, 15-inch diameter by 60-inch long complete with two 2-1/2-inch OD tangential side inlet connections, one 1-1/2-inch diameter top outlet connection, one 1-inch diameter bottom drain connection. May be arranged for receiver - mounted filtrate pump when same is finished.

2. Filtrate Pump. Pump shall be self-priming at 25-inch Hg vacuum and flooded suction, and shall be rated for 50 GPM H_2O at 40 ft total dynamic head. Motor shall be Class 1 Group D explosion proof for operation on 208/230/460 volts, 3 phase, 60 hertz. If other than direct drive, guards meeting OSHA standards shall be provided.

Item 3. Vacuum Pump.

Liquid ring vacuum pump, motor and base. Pump to be rated for 60 cfm at 20-inch Hg and 1750 rpm. Weight, seal water (at 60°F) and brake horsepower to be stated. Motor to be Class 1 Group D explosion proof for 200/208 volts 3 phase 60 hertz electric current. Pump is to be furnished complete with seal line strainer, seal water solenoid valve, and water trap-silencer.

Use of aluminum for a mounting base may be quoted as an alternate to reduce weight.

Item 4. Control Panel.

Control panel shall be explosion proof (NEMA 7) and shall include main disconnect, transformer magnetic starters, circuit breakers, start-stop switches, power "on" lights and appropriate white on black plastic nameplates. Panel shall be designed to operate on 200/208 volt, 3 phase, 60 hertz supply (initially wired for 208 volts) and shall use 115 volts for control circuits.

Item 5. Precoat Tank and Filter Feed Pump (Drawings 56615-2 and 56623-2)

A precoat tank, mixer and filter feed pump suitable for handling d.e. filter aid slurries is required together with interconnecting piping. The pump is powered by a variable speed drive with a range appropriate to the pump supplied (0.5 to 20 gpm), manually adjustable and capable of on-off automatic level control. Motors to have same characteristics as other electrical components of unit.

Item 6. Support Platform or Skid, and Assembly as a Unit

A single source supplier may choose to quote on assembling the above enumerated components as a unit on a platform or skid (or skids, see below). Because of weight limitations and the need for corrosion resistance, the skid shall be fabricated of aluminum alloy meeting ASTM Spec. B209 Alloy 6061 T6. The floor of the skid shall be checkered plated or similar non-slip material. Because of transportation limitations, a single skid may not exceed 6 ft X 8 ft. If more space than 6 ft X 8 ft is required, two skids having 6 ft as the greatest dimension shall be used. Quotations on this item must contain sufficient dimensions for proper evaluation. All wiring shall be Class 1 explosion proof. Piping external to the skid, e.g., to the filter and from the filtrate pump, will be hose connections and are not to be supplied. Unpainted metal parts other than aluminum are to be cleaned and shop primed with Tnemec No. 77 primer or equal.

APPENDIX III

ANALYTICAL DATA BY MERADCOM

JM Samples

Date	Sample	COD mg/l	TSS mg/l	TS mg/l	LOI mg/l	LOI %	Moisture % solids	LOI %	
2 June 78	4573-51-1 Filtrate	10,480	~0	9,540	4,260	44.7			
		9,728		9,500	4,240	44.6		?	
				9,600	4,360	45.4			
Sound Question	4573-51-2 Cake						46.1	99.7 residue	
							45.9	99.5	"
							45.4	99.9	"
	4573-51-3 Feed	45,600	13,294		11,019	82.9			
		47,200							
		50,400							
	4573-51-4 Filtrate	16,640		13,340	6,040	45.3			
		16,960		12,880	6,320	49.1			
		16,240		13,080	6,420	49.1			
	4573-51-5 Cake						54.0	15.9% volatile solids	
							54.4	16.6%	" "
							54.1	16.5%	" "
5 June 78	4573-52-1 Feed	37,200	8,228		7,496	91.1			
		37,440							
		35,040							
	4573-52-2 Filtrate	16,000	6.67	11,480	4,940	43.0			
		15,840		11,220	5,000	44.6			
		15,648		11,460	5,340	46.6			
	4573-52-3 Cake						46.7	18.6 volatile solids	
							46.0	18.6	"
							43.3	20.0	"
	4573-52-4 Feed	56,800	29,406		5,362	81.8			
		52,200							
		55,680							
6 June 78	4573-53-1 Filtrate	16,480	46.5	13,220	6,700	50.7			
		16,720		13,420	6,820	50.8			
				12,820	6,460	50.3			
	4573-53-2 Feed	34,000	4,744		4,248	90.2			
		~~42,400~~							
		33,120							
		30,880							
	4573-53-3 Cake						45.8	15.4 volatile solids	
							46.2	15.8	"
							46.0	15.6	"

SMEFB Form 92
17 Jun 69

-14,027—Ft Belvoir

SHEET #2

J.M. Samples

Date	Sample		COD mg/l	TSS mg/l	TS mg/l	LOI mg/l	LOI %	Moisture % Solids	LOI %	
13 June 78	4573-55-1	Feed	21,638	8,288	11,410		71.8	volatile solids		
			21,952	8,648	10,010		70.0	" "		
	4573-55-2	Filtrate	5,370	188	2,750		51.6			
			5,449		2,760		51.1			
					2,680		50.8			
	4573-55-3	Cake						44.6	22.7*	volatile solids
								44.5	20.3	"
						% from TS		44.5	20.0	"
14 June 78	4573-56-1	Feed	20,120	5,408	6,340	58.8 }	~~54.5~~	volatile solids }		
			19,360	5,820	6,420	59.0 }	68.5 "	"	} from T.S.S.	
				4,560			67.5 "	"		
	4573-56-2	Cake						47.6	15.3	volatile solids
								47.6	15.3	"
								47.7	14.9	"
	4573-56-3	Filtrate	5,940	338	2920		49.7	volatile solids		
			6,004	234	2900		48.6	"		
16 June 78	4573-57-1	Feed	16,466	5,208	12,030		64.9	" } from	T.S. 91.2	} volatile solid
			16,712	5,180	11,320		63.0	"	90.0	} from TSS
	4573-57-2	Filtrate	6,789	1.3	5,590		41.2	"		
			6,543		5,860		43.5	"		
	4573-57-3	Cake						52.7	10.5	volatile solids
								52.8	10.2	"
								52.8	10.2	"
23 June 78	4573-58-2	Feed	11,468	1,656	7,730	56	51.1 }	volatile solids		
			11,532	1,668	7,760		51.7 }	from TS	"	
				1,712	7,680		50.9 }		"	
	4573-58-1	Filtrate	7,096	4.5	5,510		38.8 }			
			7,128		5,500		37.6 }	from TS.		
					5,500		38.7 }			
	4573-58-3	Cake						52.6	12.6	volatile solids
								52.0	12.6	"
								51.7	12.3	"

SMEFB Form 92 * Small amt. loss due to dessicator vacuum scattering
17 Jun 69

-3- -34,027—Ft Belvoir

SHEET 3

JM Samples

Date	Sample		COD mg/l	TSS mg/l	TS mg/l	LOI mg/l	LOI %	Moisture % Solids	LOI %	
10 June 78	4573-59-1	Feed	11,919	1,532	8,040	60 TSS	43.4 TS			
			11,857	1,532	7,960	44	42.1			
				1,556	7,910	60	42.0			
	4573-59-2	Cake						44.9	9.1%	volatile solids
								44.6	9.9 "	" "
								44.2	11.7 "	" "
	4573-59-3	Filtrate	7,388	1.1	6,620		34.7 T.S.			
			7,388		7,050		38.3			
					6,970		38.5			
	4573-59-4	Filtrate		1.7						
	4573-59-5	Cake						43.2	12.8%	volatile solids
								43.1	13.5 "	" "
								43.1	—	
	4573-59-6	Filtrate		1.2						
	4573-59-7	Cake						42.6	15.4%	volatile solids

2 June 51-1 filtrate	didn't do
51-4 "	"
5 June 52-2 "	6.67 mg/l - filtered easily
6 June 53-1 - "	46.4 mg/l (filtered 535 ml slowly)
13 June - 55-2	* 188 mg/l - (45 ml very slowly)
14 June 56-3	#1 338 mg/l (filtered 50 ml) #2 234 mg/l
16 June 57-2	1.3 mg/l (filtered 1000 ml through easily)

APPENDIX IV

RAW FILTRATION DATA BY J-M

JOHNS-MANVILLE

BOOK No. 4573

Book 4573

5-31-78

Fort Belvoir, Va.

Project 1196 (49)

two pallets of filter aid consisting of ~~34~~ 40 Bags Hyflo
10 ~~15~~ Bags 512
10 ~~9~~ Bags 503
arrived before lunch as did the 1' x 3' rvpf.
Unit arrived without damage.
Plumbing and electrical connections were made and initial precoat check out made.

50 lbs of Hyflo was used with approximately 60 gal. of water in precoat Tank and the filter tank ½ full.
The full filter width (15"-16") took the precoat.
A 5-7" Hg vacuum was best achievable with many cracks and resulting loss of cake.

JML

Dan Lent C.O.
Jon Miller Asst.
Jerry Eskaline Boss
Chuck Chapin Chem
Ruby sec
Janet Chem
703-664-5357

Taylor Jefferson

G. R. Bell
Chas Freeman

5-31-78
5-31-78

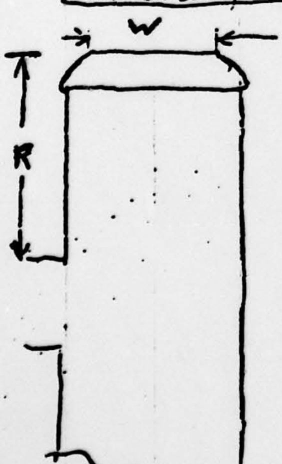
1-June 78

started by taping off drum face to 11"
then applied Hyflo precoat with initial vacuum to 12" Hg,
the top valve being closed. With continued building of precoat
to ≈ 2" cracks formed and vacuum dropped to 8-10". Shortly
cake began falling and vacuum further diminished.

A second Hyflo precoat was applied after adjusting
pH to 3-4 with H_2SO_4 vacuum situation did not improve
however cake formation was significantly improved with cracks forming
after 2" cake build up. Also cake fell and test was ended.

Next three changes were established 1) vacuum line increased to 1½"
hose. 2) 512 F.A. applied 3) Top valve full open to drum.
The drum speed run @ 55 sec/rev
Vacuum initially at 14" and increasing to 18" at 1½ cake
no cracks at this point.
(NOTE) pH held at 4
The vacuum varys from 12-23" with cracks forming when low vacuum
fluctuation & high
After lunch placed spacers in knife set up disassembled valve
at drum - drum & valve ~~[illegible]~~ were not centered adjustment made.
Knife repositioned & new precoat of 512 applied.
Vacuum again varied between 10-23" Hg.
Added locknuts to 3 bolts holding RH knife advance guide block
Stopped much of vibration.

Term Description



cake width = W

.2642 gal/liter , $8.3\bar{3} \times 10^{-5}$ ft/mil

~~Drum~~
Filter Radius = R
Total Radius = R + 4"

Area □' + cut (mil/min) + 20.5 lbs/ft³ × 60 min/hr × $8.3\bar{3} \times 10^{-5}$ ft/mil = lb/h

Vacuum submerged = Vs (vacuum on lower port) in Hg
atmosphere Va (vacuum on upper port)

Knife Advance = K.A. (from calibration data) give mil/min
filter area = actual area 2π (R+4) W ÷ 144 = sq ft.
filtration rate = dV/dt gal/sq ft hr
celatomite usage = lbs/hr

G.R. Bell 1 June 1978
John [illegible] 6-1-78

2-June 78

(51)

512 precoat applied, knife assembly working quietly, seal water to vacuum pump discharged to drain and splashing eliminated.

rough calibration made on knife advance

setting	rate (mil/min)
0	0.5
1	7.5
2	14.1

sludge filtration begun ≈ 10:00

TIME	Filtration rate	cake width (face)	Total Drum radius (face)	Knife advance
11:05	.57 gal/min	9¼	20½"	≈ 7.5 mil/min

result: 4.13 gal/sq ft hr

Sample	Time:	W	R	Vs vacuum	Va	* KA	Volume (liters/min)	gal/ft² filter AREA		dr/dt	
1	11:40	11"	16¼	23½	24½	7.5	2.07	~~34.3~~ 25	9.7	3.38	Filtrate Δ73-1 ↔ Ref K.A.
2	12:30	12⅜	15⅝	24	25	7.5	2.15	34.1	10.2 10.6	3.22	Cake Δ73-2 ←
3	1:20	12⅜	15 7/16	23½	24½	3.75	1.79	28.4	10.5	2.71	Feed-3 Filtrated
4	2:00	12⅜	15¼				1.75	27.7	8.23	3.37	cakes
	2:40	12⅜	15			5.1	1.85	29.3	8.10	3.62	
								28.5 avg	(8.94)		

good run

* Approximation based on knife movement/hr measured to 1/64"

J. R. Bell 2-June 1978

John Ziemer 6-2-78

Good

Ft Belvoir

Prepared $AlOH_3$ coated Hyflo by filling precoat tank with H_2O adding 4 lbs $Al_2(SO_4)_3 \cdot 14H_2O$ (MW = 666) dissolve then add 50 lbs Hyflo allow to slurry then add 2 lbs Na_2CO_3. The resultant precipitate is $AlOH_3 \cdot SiO_2 \cdot nH_2O$.

This coated Hyflo was precoated on to drum with no success vacuum above 10" ~~Hg~~ could not be obtained, a great deal of cracking occurred and cake dropped off.

NOTE: Vacuum reading at pump showed ~~access~~ excess of 30" Hg w/all piping disconnected + Ga. on pump suction

To establish an acceptable cake 1 12 liter Bucket of 512 was slurried in ~~feed~~ Drum tank and applied. When 10" Hg was achieved the cake had no cracks. The coated Hyflo was then pumped into Drum Tank to complete cake build up. This again cracked but vacuum built to 15" Hg & no cake was lost. Feed sludge was added and vacuum increased to 20" Hg. ~~End~~ Test Run Began at this point.

as Knife advance established surface vacuum increased to 25" Hg

sample	Time	W	R	V	KA setting	Volume	Time	Rate gal/hr	Filter area	dv/dt	mil/min	Remarks	wt usage	lbs/1000 gal
	11:00	9.25	16	25	1	12 l.	5'6"	37.3	8.07	4.62		note: 8.4 mil/min	6.95 lbs/hr	
	12:05	11.75	15 3/8	25	1	12	4'45"	42.15	9.93	4.3		8.8	8.97	
	1:00	12.25	15 1/8	24	1/2	12	5.2					12:30 KA. change		
52-1 Raw	3:00	12.25	15 1/8				5.20	37	10.15	3.6		Raw		
52-2 Filt												Filtrate		
52-3 Cake												cake		

NOTE: 1100 - 1345 .91 ~~ft/min~~/revolution

1345 slow drum speed to 1.51 ~~ft/min~~ rev.

Note 12:30 KA. to 4.9 mil/min

sample	Time	W	R	V	KA setting	Volume	Time	Rate gal/hr	Filter area	dv/dt	mil/min	Remarks	wt usage	lbs/1000 gal
	1410	12.38	17 3/4	24	1/2	12	6.4	29.7	10.13	2.93	4.9		5.09	
52-4	1500											Drum Tank		
	1505	12.38	14 1/2		1/2	12	~~6.625~~							

G. R. Bell 5 June 1978

John Keenan 6-5-78

6-6-78

53

Ft. Belvoir

Hyflo precoat with slurry pH adjusted to between 3-4 vacuum at 7
cake did not hold

Sample	Time	W	R	V	KA set.	ml/min KA rate	Vol.	Min Time	gal/hr Rate	Filter Area	dw/dt	[illegible] lbs/hr	
	7.30			7									Precoat did not hold
	8:30	Began precoat again 3" attained but with only 3-5 "Hg vacuum sludge was added and after ± 5 minutes vacuum shot up to 15											
	8 45	began dressing cake											
	9:00			22							vacuum at 22 "Hg.		
	9 35	9.5	15.15	24	3/4	9.2	12	5.95	31.97	6.53	4.91	6.16	1 minute/rev
	10:35	11.75	15.5	24	3/4	~~[illegible]~~ 9.0	12	5.7	33.37	7.95	4.2	7.5	225 lbs/1000 gal filtrate
	11:30	12.35	15	24	3/4	9.77	12	5.8	32.8	10.26	3.2	10.27	
	11:40												Drum rate adjusted to 1.74 min/rev.
573-53	12:30	12.38	14.5/8	23	3/8	5.21	12	8.2	23.2	10.6	2.31	5.72	

-1 Filtrate

-2 Feed (raw)

-3 cake

Built up of cutting on discharge Apron caused excessive local contamination from blowing cuttings

Chute plugged completely

good run

J. R. Bell

[illegible signature]

6 June 1978

6-6-78

Ft. Belvoir

With Tom Teton of Eimco present filter was precoated with Hyflo. Vacuum during precoat was at 3-5" Hg precoat went on slowly with few cracks. Drum speed was 55 sec/rev. Equipment shut down to await Larger vacuum pump. This pump arrived After lunch.

Pump Description
SIHI model 40411
108 CFM @ 20" Hg
1750 RPM

MOTOR
7½ HP
230 volt
3 PH 60 cycle
U.S. Electric MOTOR.

Installation was not completed due to the unavailability of electrical equipment to match increased motor characteristics

John Lennon
G.R. Bell

6-12-78
12 June '78

6-13-78 (55)

Fort Belvoir

Appropriate starter located and pump installation completed
Precoat Application begun
75 lbs diatomite applied at drum speed of 53 sec/rev
good cake formed. Hyflo
Sludge applied to tank and operation begun
vacuum to approximately 25" Hg

sample	Time	N	E	V	KA set	KA rate	rel	time	filtrate rate	filter area	#/ft	Diat lbs/hr	Drum speed	Avg
	11.20	10.5	16.5	25	1	9.4	12 lbs	2.57	74 g/h	9.39	7.88	9.04	53 sec/rev	
	12.20	12.38	16.0	25	1	9.4	12	3.08	61.8	10.8	5.12	10.4	55 sec/rev	
1	12:40		feed											
2	12:30		filtrate											
3	12.30		cake											
	1310	12.33	15.63	25	1	9.6	12	2.93	64.92	10.6	6.12	10.43	55/rev	

note. pinion sprocket 13 teeth
Driven sprocket 60 teeth

Goodin

[signature] 6-13-78

J. R. Bell 13-June 1978

6-14-78

1186

56

Fort Belvoir

Precoated with 503
Precoat time 30 min for 2⅛" cake stopped because cake appeared to be at point where it might fall off 20" Hg at this point.
Vacuum could be controlled to some extent at petcock at pump. Attempt to run at 20" Hg on submerge side of drum

Sample	Time	W	C	V	Kil. Set	Kil Rate	icl	Time	Filtrate rate	AREA	% kit	DIAT. wt	Drum speed	
	9:35	12	16.5	20	1		12	2.38	71.9%	10.73	7.45		57 min/rev	
	10:35	12.3?	15.75	20	1	9.1	12	2.55	74.6	10.67	8.0?	9.95	57	
	11:25	12.38	15.25	20	1	9.3	12	2.32	82.0	10.40	7.8?	9.91	57	
	12:40	12.38	14.5	19	1	8.1	12	2.17	87.7	10.53	8.33	8.79	53	29% submerge
1	Sludge													
2	cake													
3	filtrate													

2:00 shut down after cake reached ½" thickness

good run

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John Larson — 6-14-78

G.R. Bell — 14 June 1978

6-16-78

(57)

Fresh Feed was received by noon

10 TOOTH sprocket on drive shaft of Knife Advance motor. replaced 13 tooth.

For Aging Test Hyflo will be used as precoat

sample	Time	W	e	V	K.A. set	K.A. Rate (mil/min)	vol	Time	rate	area	per hr. (gal/sqft hr.)	usage	Drum speed
	1315	Begin precoat : vacuum at 10 in Hg precoat cracked badly and fell of when ≈ 3" WERE on THE Drum											
		Therefore acidify to 3 pH											
	1350	Begin Precoat vacuum 15" Hg											

1 - Feed
2 - Filtrate
3 - cake

precoat rate

	Time	W	e	V	K.A. set	K.A. Rate	vol	Time	rate	area	per hr.	usage	Drum speed	
													1 rev/min	
	1530	12.25	16.25	20	1/2	5.9	12	4.98	38.2	10.82	3.53		.46 rev/min	
	1600	12.38	16 1/16	20.5	1/2	5.5	12	4.82	39.46	10.84	3.64		.46	
	1615	12.38	15 15/16	20.5	1/2		12	5.03	37.82	10.77	3.51		"	
	1630	12.38	15 7/8	20.5	1/2		12	4.90	38.82	10.74	3.61			setting of
	1705	12.38	15 5/8	20.5	1/2	5.5	12	4.55	41.8	10.60	3.94			drum drive 4 1/2
	1730	12.38	15 9/16	20.75	1/2	5.4	12	4.22	45.0	10.57	4.26		.46	
									(40.2)		Avg = 3.75			

MC-1000 was added to feed to reduce odor

good run

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John Leaman 6-16-78

J. R. Bill 3 July 1978

Ft Belvoir

Began precoat @ 8:30
Hyflo (50lbs) acidified with H_2SO_4 to pH 3
Drum speed 67 secs/rev
vacuum during precoat 20" Hg
drum speed reduced to setting of 4½ (.47 rev/min)

Sample	Time	W	e	V	KA	KA Data	Vol	Time	AREA	dv/dt	gsfh wight Dry
			16 1/16								
	920	9 3/8	16 1/16	20	1/2		12	2'24"	8.21		9.65
	950	10 1/2	15 15/16	20 1/2	1/2	5.4	12	2'37"	9.13		7.96
1	Filtrate										
2	raw										
3	cake										
	10:30	11 1/4	15 3/4	20 1/2	1/2		12	2'50"	9.69	~~4.24~~	6.93
	1100	11 7/8	15 9/16	20 1/2	1/2	5.4	12	2'46"	10.14		6.78
	1145	12 1/4	15 3/8	20 1/2	1/2		12	1'58"	10.57		7.15
	1225	12 3/8	15 1/4	20 1/2	1/2	5.4	12	2'46"	10.40		6.6
	1240	12 3/8	15 1/16	20 1/2	1/2	5.5	12	2'46	10.30		6.70
								Avg (68.75)			
										Avg	7.68

Equipment worked well!

Good Run

John Leamon
G. R. Bell

6-23-78
3-July 1978

6-30-78

(59)

Ft. Belvoir

Hyflo

Sample	~~Date~~	W	R	V	K.A	Rate KA	vol	time	area	dv/dt	Rate ure	Drum			
59-1	7:45		Raw Feed												
	8:15										Start Precoat				
	8:50			10 Hz							End Precoating				
	8:50										Start Filtration				
	9:00		Change gear direction on K.A.												
	9:40	11	16 9/16	20.5			11	1'53"				Drum	speed	50sec/rev	
	10:00	11 1/2	16 7/16	20.5			11	2'21"				"	"	1'36"/rev	
	10:30	12	16 1/4	20 1/2	5	5.4	11	2'30"	10.60	6.58		\			
59-2		cake													
59-3		filtrate													
	11:00	12 3/8	16 3/16	20 1/2	5	5.0	11	2'34	10.9	6.23		1'36"	—		
	11:15	12 3/8	16	20 1/2	3	3.26	11	3'00	10.8	5.38		1'23"	—		
59-4	11:15 filtrate														
59-5		Sludge cake													
	11:30	12 3/8	16	20 1/2	3	3.26	11	3'01"	10.8	5.35		125"			
	11:45	12 3/8	16	20 1/2	3	3.26	11	2'46"	10.8	5.84		52"			
59-6	12:00	12 3/8	15 15/16	20 1/2	3	3.4	11	2'47	10.71	5.85		52"	— filtrate		
-7	12:00												cake		
	12:15	12 3/8	15 7/8	20 1/2	5	5.6	11	2'11"	10.7±	7.44		52"	—		

Good run

[signature]
J. F. Bell

6-30-78
3 July 1978